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NATIONAL DAM SAFETY PROGRAM. DESOTO MINING CO. PIT AND PLANT 'B'--ETC(U)
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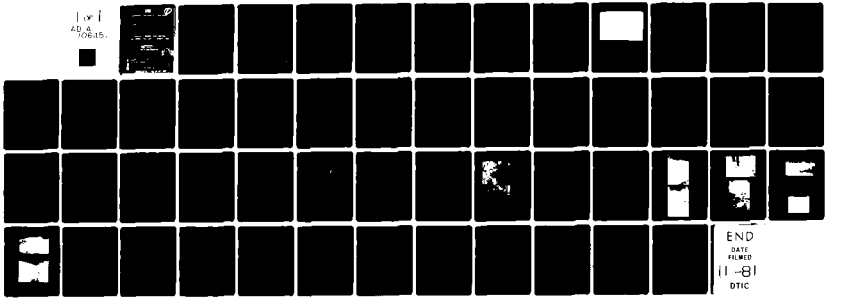

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE . .MY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Desoto Mining Co. Pit & Plant 'B' Dam (MO 30469) Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Desoto Mining Co. Pit & Plant 'B' Dam MO 30469.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

1. This dam, which has no formal spillway, cannot retain the 10-year frequency flood without overtopping of the dam occurring.

2. Overtopping could result in dam failure.

3. Dam failure significantly increases the hazard to life and property downstream.

For Phase I reports, the extent of the downstream damage zone has been determined assuming that all materials contained by the tailings dam are in a liquid state.

SUBMITTED BY: SIGNED 29 SEP 1980
Chief, Engineering Division — Date

APPROVED BY: SIGNED 29 SEP 1980
Colonel, CE, District Engineer — Date

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DESOTO MINING CO.

PIT & PLANT "B" DAM

Washington County, Missouri

Missouri Inventory No. 30469

Phase I Inspection Report

National Dam Safety Program.

Desoto Mining Co. Pit and Plant 'B' Dam (MO 30469), Mississippi - Kaskaskia - St. Louis Basin. Washington County, Missouri. Phase I Inspection Report.

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

(9) Final rept.,

15 DACW43-80-C-0066

10 Richard G. /Berggreen
Leonard M. /Krazynski

Under Direction of

St Louis District, Corps of Engineers

(12)

for

Governor of Missouri

(11) Sept[redacted]80

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Desoto Mining Company Pit and Plant "B" Dam
State Located	Missouri
County Located	Washington
Stream	Ditch Creek
Date of Inspection	4 June 1980

The Desoto Mining Company Pit and Plant "B" Dam, Missouri Inventory Number 30469, was inspected by Richard Berggreen (engineering geologist), Dave Hendron (geotechnical engineer), and Sean Tseng (hydrologist). The dam is an active barite tailings dam.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. They are intended to provide an expeditious identification, based on available data and a visual inspection, of those dams which may pose hazards to human life or property. In view of the limited nature of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers, has classified this dam high hazard; we concur with this classification. The estimated damage zone extends thirteen mi below the dam. There are at least eight occupied or vacation homes and four state highways in this hazard zone.

The Pit and Plant "B" Dam is in the intermediate size classification based on its 55 ft maximum height. Water storage in the reservoir is approximately 200 ac-ft. Intermediate dams are from 40 to 100 ft in height and 1,000 to 50,000 ac-ft in storage.

Our inspection and evaluation indicate the dam is in generally poor condition. There is no designed spillway at this facility. Overflow at the dam crest would likely result in significant erosion of the embankment, due to the embankment materials and construction methods. Significant erosion could lead to failure of this dam.

The slopes of the face of the embankment are excessively steep, 33 to 36°, and the long term stability of these slopes is questionable.

Hydrologic analyses indicate the 10 percent probability-of-occurrence event will overtop the embankment. The analyses also indicate that since the high water mark is at the minimum top of dam, one percent of the Probable Maximum Flood (PMF) will overtop the embankment. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

There is no inspection or monitoring program in effect at this facility. This is considered a deficiency.

It is recommended that an inspection and monitoring program be initiated at this facility. This program should include:

1. Periodic inspection of the embankment crest and slopes to identify evidence of instability such as cracking or slumping.

2. Monitoring of seepage at the toe of the dam to identify changes in the volume of flow or turbidity in the seepage water.

It is recommended that a hydrologic analysis be conducted to facilitate the design of a spillway and discharge channel which will meet the following objectives:

1. Minimize storage behind the dam.

2. Allow passage of the PMF event without overtopping the dam.

3. Direct the discharge channel so erosion of the toe of the embankment will not occur.

It is recommended static and seismic stability analyses be performed on the existing structure by an engineer experienced in the design and construction of dams. These analyses should also include a seepage analysis to meet the criteria of the recommended guidelines.

It is recommended the owner take action on these recommendations immediately.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
Registered Geologist

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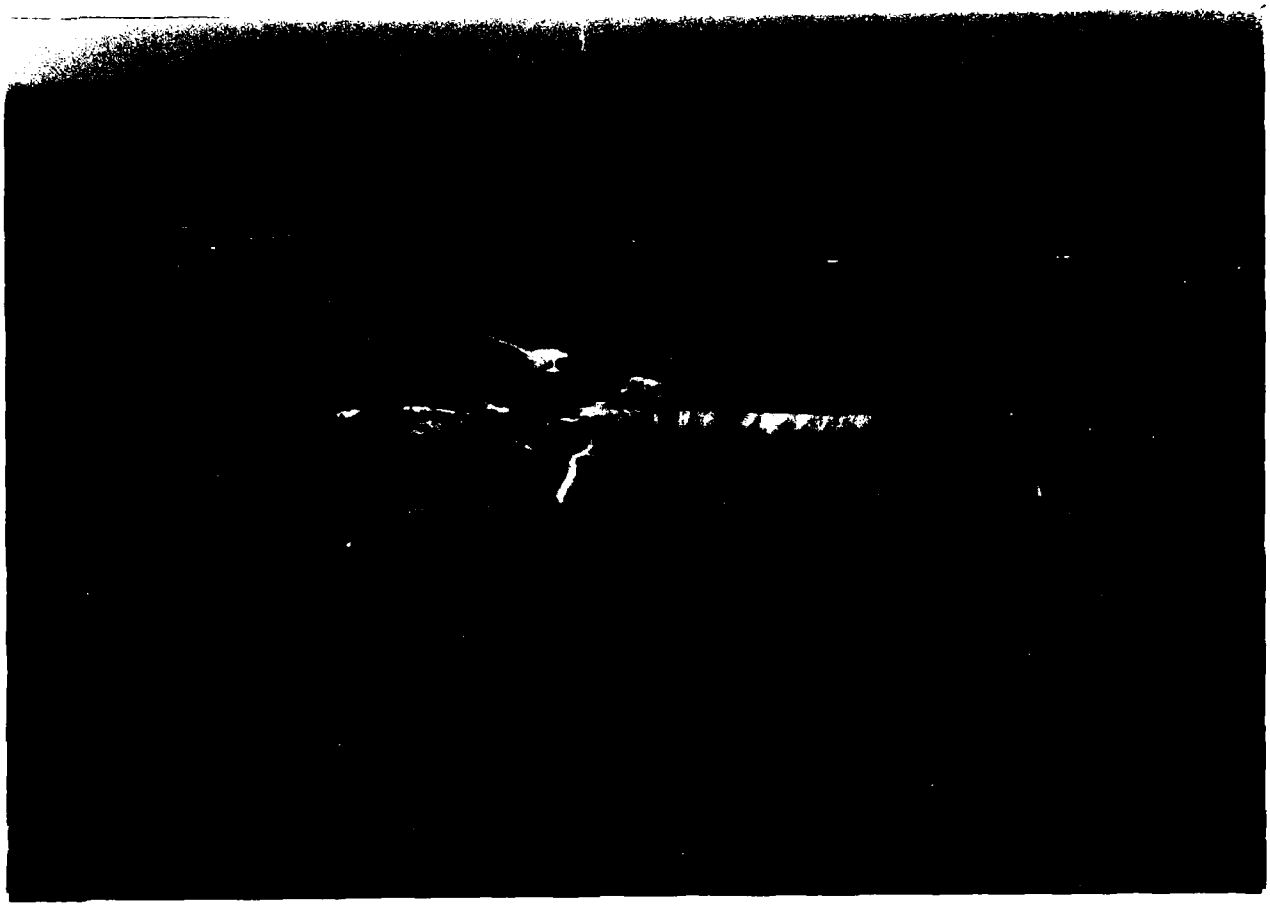
Vice President



OVERVIEW
DESOTO MINING CO
PIT & PLANT 'B' DAM

MISSOURI INVENTORY NO. 30469

Desoto Pit & Plant B
in foreground

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DESOTO MINING CO.
PIT & PLANT "B" DAM - MISSOURI INVENTORY NO. 30469

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3a. Surveyed Topography of Dam and Reservoir
3b. Profile and Section of Dam
4. Regional Geologic Map

APPENDICES

A Figure A-1: Photo Location Sketch

Photographs

1. "Bullrock" cover on face of dam showing sliding to toe. Looking west (upstream).
2. Exposed bedrock at toe of dam. Looking west (upstream).
3. Seepage from near bedrock contact of right abutment.
4. "Bullrock" slope cover and pond at toe of dam. Looking east (downstream).
5. Vegetation on upstream side of dam crest. Looking southeast from baffle dike in center of reservoir.
6. Foreground is dense vegetation in north half of impoundment. Dam 31404 in background. Looking west.
7. "Bullrock" and clay matrix dumped as slope erosion protection. Looking north along dam crest.
8. Overland erosion channel at toe of dam. Looking northwest.

B Hydraulic/Hydrologic Data and Analyses

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DESOTO MINING CO.
PIT & PLANT "B" DAM, MISSOURI INVENTORY NO. 30469

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Desoto Mining Co. Pit & Plant "B" Dam, Missouri Inventory Number 30469.

b. **Purpose of Inspection.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property. The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted." (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams", prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards Phase I Safety Inspection of Non-Federal Dams" prepared by the St Louis District, Corps of Engineers. These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Pit and Plant B Dam is an active tailings dam. It is the lower of two tandem settling ponds, the upper pool being Richwoods Mine B Mill Dam, MO 31404. Its construction procedure and usage is typical of other barite tailings dam in the area. The unique nature of tailings dams has a significant impact on their evaluation. A brief description of the construction procedure and usage of Missouri barite tailings dams is necessary to understand the differences between this dam and a conventional water-retaining dam.

At the start of a barite mining operation in this area, a 10 to 20 ft high starter dam is typically constructed across a natural stream channel. Generally the streams are intermittent so that construction is carried out in the dry. Trees and other vegetation are removed from the dam site and a cutoff is often made to shallow bedrock. Locally obtained earth, usually a gravelly clay, is then placed to form the embankment. Compaction is limited to that provided by the equipment.

The barite ore is contained within the local deposits of residual gravelly clay which is mined with earth-moving equipment. At the processing plant, the ore is washed to loosen and remove the soil. This water is obtained from the reservoir area behind the dam. The soil-laden, wash water (and water from other steps in the process) is then discharged into the reservoir. There the soil is deposited by sedimentation and the water recycled. Another step in the process removes the broken gravel-sized waste which is called "chat".

As the level of the fine tailings increases, the dam is raised. The usual method is to place chat, by dumping, on the dam crest. Then the chat is spread over the crest so that a relatively constant crest width is maintained as the dam is raised. Generally the crest centerline location is also maintained. However, the crest centerline location may migrate upstream if there is insufficient chat available and downstream if an excessive quantity of chat is available. The latter is uncommon because it is indicative of a poor ore deposit.

This method of construction results in slopes which are close to the natural angle of repose for the chat. They can be considered to be near a state of incipient failure.

A large quantity of water is required for a processing operation, on the order of 2000 to 5000 gal/min. Thus it has been the operators' practice to construct the dam so that all inflow to the reservoir is recycled in order to have sufficient water for the operation; the result being that formal spillways or regulating outlets are generally not constructed. In most cases a low point on or near the dam is provided should the storage capacity be exceeded.

The fine tailings typically fill more than 80 percent of the total storage volume. This results from the operator's practice of maintaining only a 2 to 5 ft elevation differential between the level of the tailings and the dam crest. The differential is usually greater further away from the discharge point and also typically farther away from the dam.

The geotechnical characteristics of the fine tailings are somewhat similar to recent lacustrine clay deposits. Where the tailings have been continuously submerged, they have a very soft consistency and high water contents. When evaporation causes the water level to recede and the tailings are exposed, a stiff crust forms as the tailings dry out. Below the crust, the tailings retain their soft consistency for long periods of time. Their consistency is gradually modified by a slow process of consolidation.

Pit and Plant B Dam is representative of barite tailings dams. The embankment is composed of chat. The downstream slope is very steep and the upstream slope is covered by the fine tailings, bushes and trees. There are no regulating outlets. A spillway has not been constructed; flow from the reservoir passes through a low area at the south end of the dam, onto a brush covered slope and into a pond near the toe of the dam. Dimensions are presented in Section 1.3.

b. **Location.** The dam is located off Missouri Highway 47, 2.0 mi NE of Richwoods, Washington County, Missouri (Fig. 1). It is located on Ditch Creek in the Washington County Barite District, Survey #2161, USGS Richwoods NE 7.5 minute quadrangle map.

c. **Size classification.** The dam is classified intermediate size based on its 55 ft height. The reservoir impounds approximately 200 ac-ft of water. This does not include the volume of fine tailings in the impoundment. Intermediate dams are from 40 to 100 ft in height and 1,000 to 50,000 ac-ft in storage capacity.

d. **Hazard classification.** The St. Louis District, Corps of Engineers (SLD) has classified the dam as high hazard; we concur with this classification. The estimated damage zone extends thirteen miles downstream of the dam. There are at least 8 occupied or vacation home structures and 4 highways within the estimated damage zone. As a result the potential for loss of life and property is high.

e. **Ownership.** The dam is reportedly owned by Desoto Mining Co, Box 35, Richwoods, Missouri 63071. Correspondence should be addressed to Mr Durward Spees.

f. **Purpose of dam.** The dam was constructed to impound fine barite tailings produced by washing of barite ore mined in the area. Water containing the tailings was discharged into the reservoir where the tailings settled out. Clear water was then recycled to the processing plant.

At present, tailings are being discharged into the Richwoods Mine B Mill pond (MO 31404) upstream where most of the tailings are deposited. Excess water containing some fine-grained material then returns through a series of ditches and small ponds to the Desoto Pit and Plant B pond where the fine fraction settles and the water is recycled through the processing plant by pumping.

g. **Design and construction history.** The owner has no record of the design and construction of the dam. Construction is apparently as described in Section 1.2a.

h. **Normal operating procedures.** No operation records were found. Circulation of fluid in and out of the pond is as described in Section 1.2f.

1.3 Pertinent Data

a. **Drainage area.** The drainage area was measured as .37 mi^2 on the advance print of the USGS Richwoods NE 7.5-minute quadrangle map (Fig. 2). This includes the drainage area for the Richwoods Mine B Mill Dam immediately upstream from the Pit and Plant B Dam.

b. **Discharge at damsite.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	No spillway
Total spillway capacity at maximum pool elevation	No spillway

c. **Elevation (ft above MSL).**

Top of dam	834 to 842
Maximum pool-design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Streambed at toe of maximum section	787
Maximum tailwater	Unknown

d. **Reservoir.**

Length of maximum pool	800 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam (live storage)	198

f. **Reservoir surface (acres).**

Top of dam	21
Maximum pool	21
Flood-control pool	N/A
Recreation pool	N/A
Spillway crest	N/A

g. **Dam.**

Type	Tailings
Length	1200 ft
Height	55 ft
Top width	40 to 45 ft
Side slopes	Downstream, 1.6 (H) to 1(V); Upstream, unknown
Zoning	Unknown (probably none)
Impervious core	Unknown (probably none)
Cutoff	Unknown (probably trench to shallow rock)
Grout curtain	Unknown (probably none)

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. **Spillway.**

Type	No formal spillway. Emergency discharge over low area in south end of embankment
Length of weir	N/A
Crest elevation	834 ft
Gates	N/A
U/S channel	N/A
D/S channel	Unlined earth and rock slope

j. **Regulating outlets.** None

SECTION 2
ENGINEERING DATA

2.1 Design

No design drawings or other design data were found.

2.2 Construction

No construction records were found. Typical construction techniques are presented in Section 1.2a.

2.3 Operation

No operation records are known to exist.

2.4 Evaluation

a. **Availability.** No engineering data were available for this dam.

b. **Adequacy.** The available information is insufficient to evaluate the design of Pit and Plant B Dam.

Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of dams.

c. **Validity.** Not applicable.

2.5 Project Geology

The dam site lies on the northern flank of the Ozark structural dome. The regional dip is to the north. The bedrock in the area is mapped as Cambrian age Eminence

and Potosi dolomite formations on the Geologic Map of Missouri (Fig. 4). The Potosi Formation is a light gray, medium to fine grained dolomite which typically contains an abundance of quartz druse characteristic of chert-bearing formations. The Eminence Formation, which conformably overlies the Potosi Formation, is similar in appearance, but contains less quartz and chert.

The soil at the dam site is a dark red-brown, stoney, plastic residual clay (CH), characteristically developed on the Potosi formation. It is locally overlain by a 1 to 5 ft thick silty loess (ML). The area is mapped on the Missouri General Soils Map as Union-Goss-Gasconade-Peridge Association.

The Richwoods Fault zone lies approximately 2 mi south of the dam site and is mapped on the Structural Features Map of Missouri (1971) as discontinuous for approximately 19 mi, in a WNW-ESE direction. The Ditch Creek Fault System is located about 3 mi north of the site and is mapped on the Structural Features Map as approximately 11 mi long, paralleling the Richwoods Fault zone. The Ditch Creek System is mapped as north side down; the Richwoods fault is mapped as north side up. The faults are likely Paleozoic in age, and are not in a seismically active area. These faults are not considered to pose a significant hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** Dam was inspected on 4 June 1980 without an owner's representative present. This inspection indicated the dam is in a generally poor condition.

b. **Dam.** The embankment is composed of coarse tailings or "chat". This material (gravel, sandy gravel and sand; GW, SW) is cohesionless and permeable and would likely be severely eroded if the dam were overtopped. The embankment appeared to be extremely steep, on the order of 33-36°, and the downstream slope could be subject to failure if significantly disturbed. No evidence of previous overtopping was noted during the visual inspection. The upstream face is covered with fine tailings, bushes and trees.

No evidence of serious erosion, detrimental settlement, depressions, cracking, slope instability, sinkholes or animal burrows was found during the inspection.

Clear seepage amounting to about 10 gal/min was observed about 40 ft from the downstream toe of the right abutment (Fig. A-1 Appendix A). The seepage appeared to be flowing along the residual soil/bedrock contact.

c. **Appurtenant Structures.**

1. Spillway. No designed spillway was constructed for this dam. Excess water from the pond would be discharged through a low area in the crest of the embankment at the right abutment.

d. **Reservoir area.** Approximately 50 percent of the surface of the impoundment area was above the water level at the time of inspection, primarily to the north of the baffle dike which splits the pond (See Fig. A-1). This area is underlain by tailings consisting primarily of an impervious mixture of sand, silt and clay. Dense willow-type vegetation is growing on the tailings surface.

Except for the downstream face of Richwoods B Mill Dam (MO 31404), immediately upstream of the reservoir, slopes in the reservoir area are relatively flat and estimated to be less than 10(H) to 1(V). The steep face of the upstream Richwoods Mine B Mill Dam, 33 to 35°, the saturated conditions at the toe of that dam, and the continued raising of that dam suggest the possibility of slope instability and failure into the reservoir of the Pit and Plant B Dam.

e. **Discharge channel.** Overflow from the reservoir would pass over a brushy slope into a shallow swale about 200 ft downstream of the dam and then to a pond below the dam. There is no well-defined channel as such. Distance to the pond from the notch at the south abutment is about 500 ft.

3.2 Evaluation

At present the dam appears to be in poor condition. There is no formal spillway or discharge channel at this dam. Overtopping of the dam would likely cause significant erosion which could lead to the failure of this dam. No signs or records of overtopping were located during the field inspection. No signs of failure, cracking, erosion, animal burrows, settlement or sinkhole development were noted. Seepage noted near the toe of the dam did not appear to be a hazard due to the low volume of flow and lack of suspended sediment in the seepage water.

The growth of bushes and trees in the fine tailings covering the upstream face of the dam provides adequate protection against severe wave erosion. It is unlikely large waves will develop in this reservoir due to the relatively short reach (800 ft).

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

There are no formal operating procedures for this dam.

4.2 Maintenance of Dam

There are no organized maintenance procedures other than raising of the dam crest as the level of tailings increases in the impoundment and placing bullrock by dumping, on the downstream face of the dam for erosion protection.

4.3 Maintenance of Operating Facilities

No operating facilities exist at this dam which require maintenance.

4.4 Description of any Warning System in Effect

Our visual inspection did not identify any warning system in effect at this dam.

4.5 Evaluation

There is no formal plan for periodic inspection nor performance of maintenance. This is considered a deficiency.

The feasibility of a practical warning system should be evaluated to alert downstream residents and traffic should potentially hazardous conditions develop during periods of heavy precipitation.

SECTION 5
HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic design information was available for evaluation of the dam or the reservoir; however, contour maps prepared in spring, 1980 (Scale: 1 in. = 200 ft) were supplied by Desoto Mining Co. Other dimensions of the dam and reservoir were measured on the date of inspection or estimated from topographic mapping. The map used in the analysis is the advance print of the USGS Richwoods NE 7.5 minute quadrangle sheet.

b. **Experience data.** No recorded rainfall, runoff, discharge, or pool stage data were available for this reservoir and dam.

c. **Visual observations.** The visual inspection identified no designed spillway or discharge channel at this dam. The dam and reservoir are part of a closed system for recycling water used in processing the barite ore. No overflow structure was constructed and no records or evidence of overflow could be found. The visual inspection indicated the dam could be severely eroded in the event of overtopping as a result of the cohesionless nature of much of the embankment.

Other visual observations regarding the reservoir, embankment and downstream channel are presented in Section 3, Visual Inspection.

d. **Overtopping potential.** The hydrologic/hydraulic analysis performed for this dam indicate there is insufficient storage to contain the 10 percent probability-of-occurrence event. As there is no formal spillway overflow would pass over the erodible face and crest of the dam. Inasmuch as it is assumed the antecedent storm will result in a full reservoir, overtopping will occur with any fraction of the Probable Maximum Flood (PMF). The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

The following table presents the expected severity of overtopping for various precipitation events:

Precipitation Event	Max. Reservoir W.S. Elev.	Max. Depth over Dam, ft	Max. Outflow, ft^3/sec	Duration of Overtopping, hrs
0% PMF	834.0 (top of dam)	0	0	0
50% PMF	836.81	2.81	1546	48
100% PMF	837.35	3.35	2387	48

As the embankment materials are highly erodible, overtopping could lead to failure of the dam. Velocities in the overtopped portions of the dam are anticipated to be sufficient to cause severe erosion (that is, greater than 3.5 ft/sec). As the spillway is at the abutment of the dam, erosion will likely encounter bedrock at relatively shallow depths, perhaps 10 ft. However, the erosion could migrate into the embankment and, given sufficient overtopping duration, eventually result in failure of the dam.

The analysis of the hydrology and hydraulics for this dam has included the hypothetical breach of the upstream dam, Richwoods Mine B Mill Dam (MO 31404). The breach parameters are as outlined in the St Louis District Hydrology and Hydraulics Standards for multiple dam evaluation.

Hydraulic/hydrologic input data and output summaries are presented in Appendix B.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** Features identified during the visual inspection which adversely affect the structural stability of this dam are reported in Section 3. Of primary importance are the erodible nature of the embankment and the lack of an adequate spillway or discharge channel.

b. **Design and construction data.** No design or construction data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be corrected to meet the recommended guidelines.

c. **Operating records.** No appurtenant structures requiring operation exist at this dam.

d. **Post construction changes.** The dam and reservoir are still active. Construction of the dam continues by means of adding chat to the dam crest and bullrock (coarse tailings and clay) to the face of the dam. No other changes were noted during the inspection.

e. **Seismic stability.** The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. Since no static stability analysis is available for review, the seismic stability cannot be evaluated. However, as the tailings are fine-grained, saturated materials and the dam is of loose, granular material, substantial deformation or failure could occur in the event of a severe seismic event.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, Pit and Plant B Dam appears to be in generally poor condition. This is based primarily on the lack of a designed spillway and the potential for severe erosion of the crest and face of the dam in the event of overtopping. The extremely steep downstream face is also of questionable stability.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

As a consequence of the widely-used construction procedure, the slopes of the tailings dams are placed at the angle of natural repose for the material at any given operation. This results in slopes that are very steep and exist close to incipient failure with safety factors approximately equal to one. This situation is subject to some gradual improvement with time as consolidation and/or dessication of the fine-grained tailings result in an increase in strength.

The slopes placed at an angle of natural repose will only remain stable, if they are protected against changes that increase loading or decrease strength. Such changes include, but may not be limited to, the following:

1. Overtopping by water.

2. Higher pore pressures (or seepage forces).

3. Undercutting of the toe of the slope by erosion or mining activity.

4. Increase in the height of the dam (applicable to active operations).

5. Liquefaction (such as may result from a seismic event).

The first four changes are subject to control by owners and operators and must receive careful attention in order to maintain stable and safe dam embankments. The fifth influence represents a risk the magnitude of which is not well understood without further study.

b. **Adequacy of information.** Stability and seepage analyses comparable to the requirements of the guidelines are not on record. Evaluation of the structural and seismic stability of the dam, therefore, cannot be made at this time.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Corrective actions should be initiated immediately.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspection of Dams", the subject investigation was a minimum study. This study revealed that additional in-depth investigations as described in Sec 7.2.b are needed to complete the assessment of the safety of the dam. It is our understanding from discussions with the St Louis District that these additional in-depth investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam, or breach it to prevent storage of water.

2. Increase the height of dam and/or spillway size to pass the Probable Maximum Flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Enhance the stability of the dam to permit overtopping by the Probable Maximum Flood without failure.

5. Provide a highly reliable flood warning system (generally does not prevent damage but decreases chances of loss of life).

b. **Recommendations.** Based on our inspection of Desoto Pit and Plant B Dam, it is recommended that further study be conducted without undue delay to evaluate, as a minimum:

1. What spillway capacity should be provided and in what manner, taking into consideration the high potential erodibility of the embankment materials.

2. Potential for erosion during periods of heavy flow in the discharge channel and along the toe of the embankment.

c. **O & M procedures.** A program of periodic inspections is recommended for the Desoto Mining Company Pit and Plant B Dam. This program should include, but not be limited to:

1. Inspection of seepage areas to identify increases in volume of seepage or turbidity (soil) in the seepage water.

2. Inspection of slopes to identify evidence of slope instability such as cracking or slumping of the embankment.

Seepage and stability analyses should be performed by a professional engineer experienced in the design and construction of dams.

Records should be kept of the inspections and any required maintenance. All remedial measures should be performed under the guidance of an engineer experienced in the design and construction of dams.

The evaluation of a practical and effective warning system is recommended to alert downstream traffic and residents should hazardous conditions develop at this dam.

REFERENCES

Allgood, Ferris P., and Persinger, Ivan, D., 1979, "Missouri General Soil Map and Soil Association Descriptions," US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

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Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".

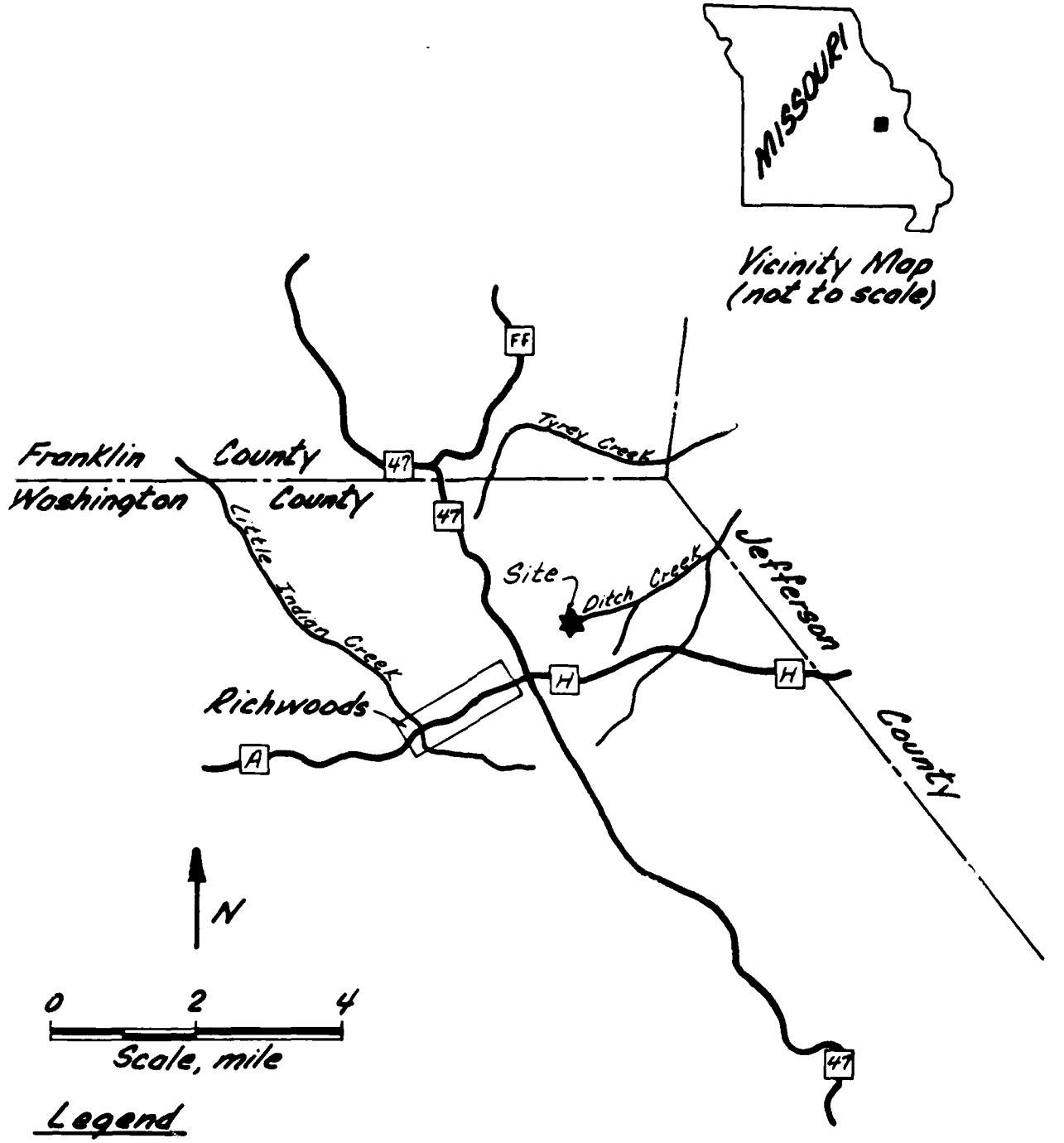
McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

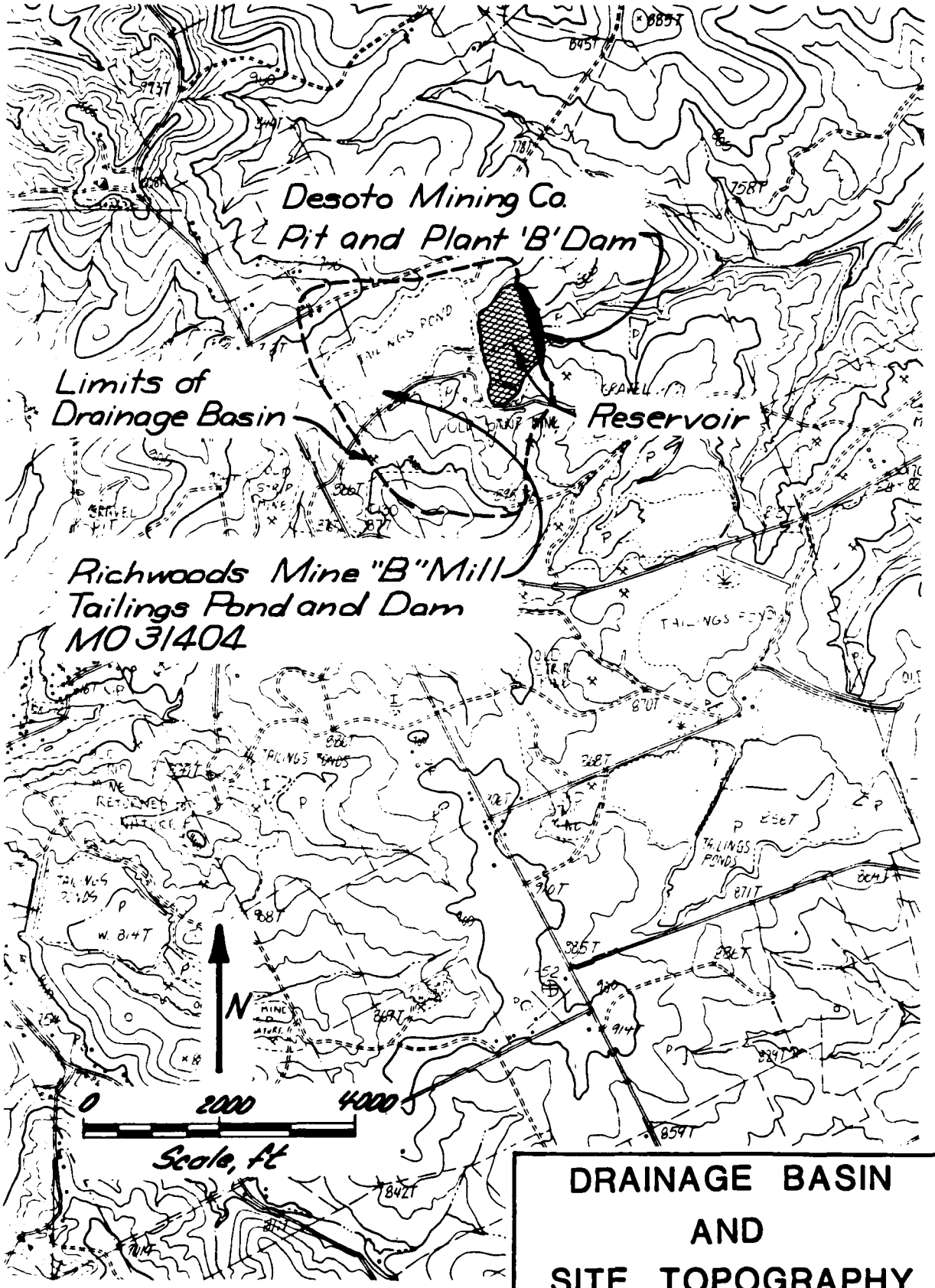
US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



SITE LOCATION MAP

DESOTO MINING CO PIT & PLANT 'B' DAM

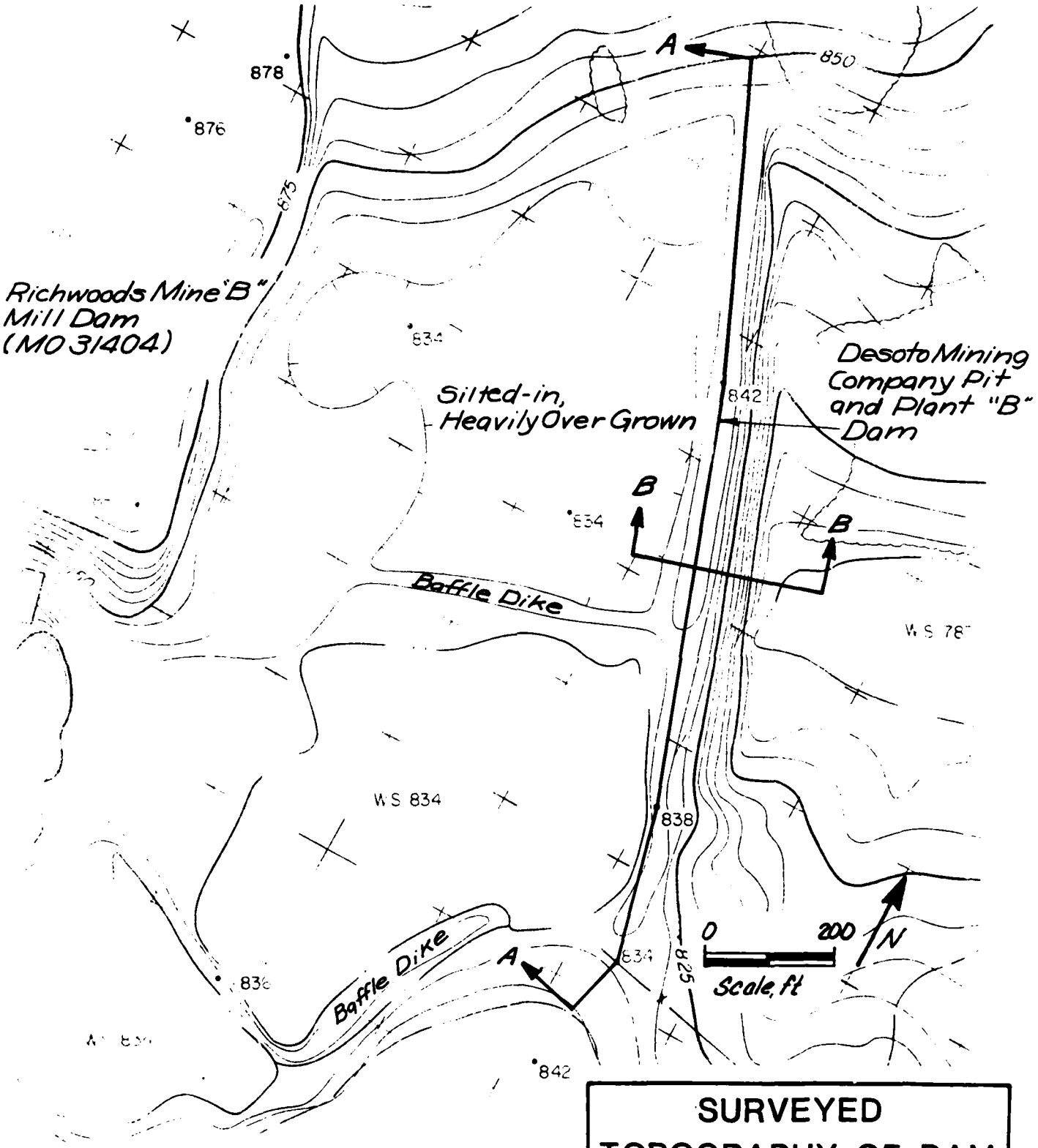
MO. 30469 | Fig. 1



1. Topography from U.S.G.S. Richwoods NE 7½ minute quadrangle map.

DRAINAGE BASIN AND SITE TOPOGRAPHY

DESOTO MINING CO PIT & PLANT 'B' DAM	
MO. 30469	Fig. 2



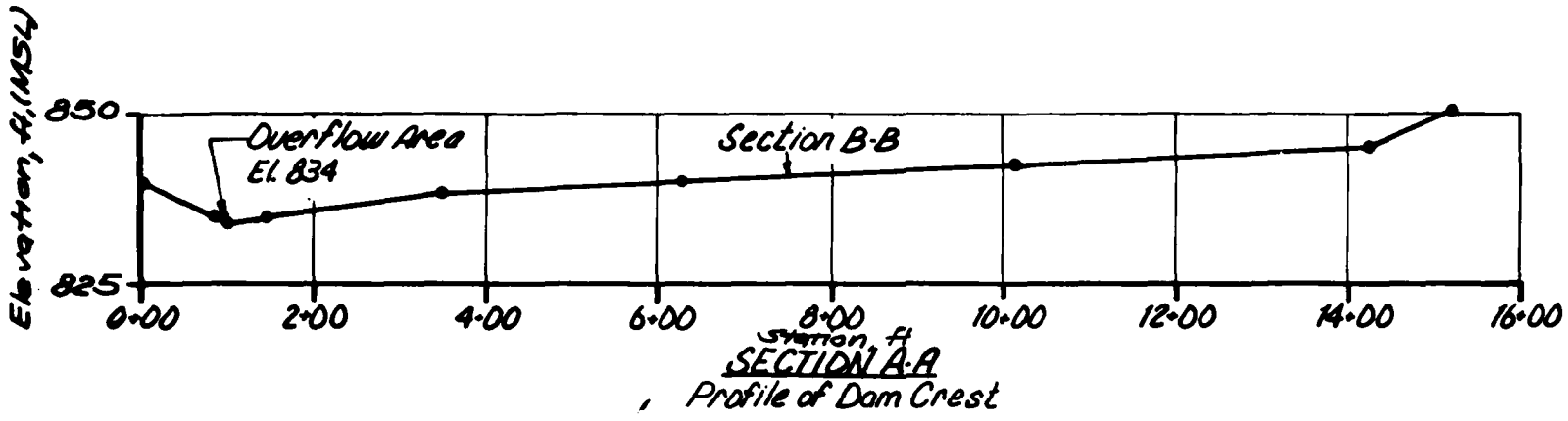
NOTES:

Surveyed Spring 1980 by Owen Ayers and Associates, Inc., Madison, Wisconsin

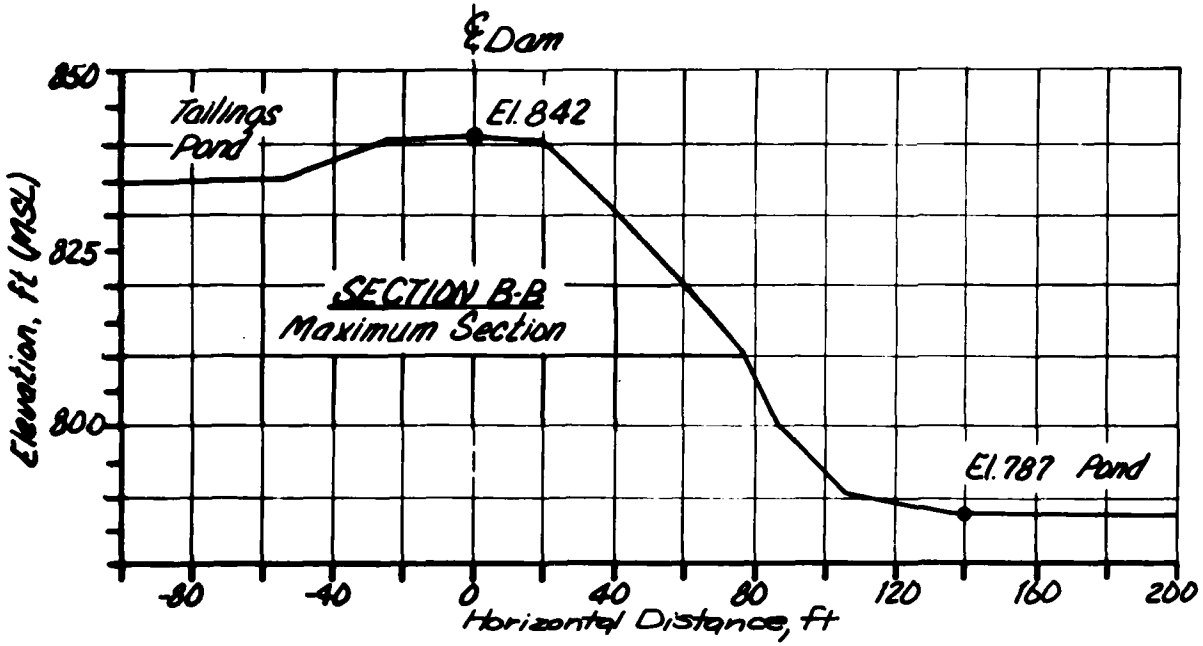
W.S. indicates Water-Surface elevation

Contour interval 5 ft

SURVEYED TOPOGRAPHY OF DAM AND RESERVOIR	
DESOTO MINING CO PIT & PLANT 'B' DAM	
MO. 30469	Fig. 3 A



SECTION A-A
Profile of Dam Crest



PROFILE AND SECTION OF DAM	
DESOTO MINING CO PIT & PLANT 'B' DAM	
MO30469	Fig.3-B

Legend

- Or — Roubidoux Formation
- Gasconade Dolomite
  - Gunter Sandstone Member
- Cep — Eminence Dolomite
- Cep — Potosi Dolomite
- Derby-Doerun Dolomite
- Ceb — Davis Formation
- Bonneterre Formation
  - Whetstone Creek Member
  - Sullivan Siltstone Member
- Reagan Sandstone (subsurface, western Missouri)
- Lamotte Sandstone
- Diabase (dikes and sills)
- St. Francois Mountains Intrusive Suite
- St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

DESOTO MINING CO PIT & PLANT 'B' DAM

MO. 30469	Fig. 4

APPENDIX A

Photographs

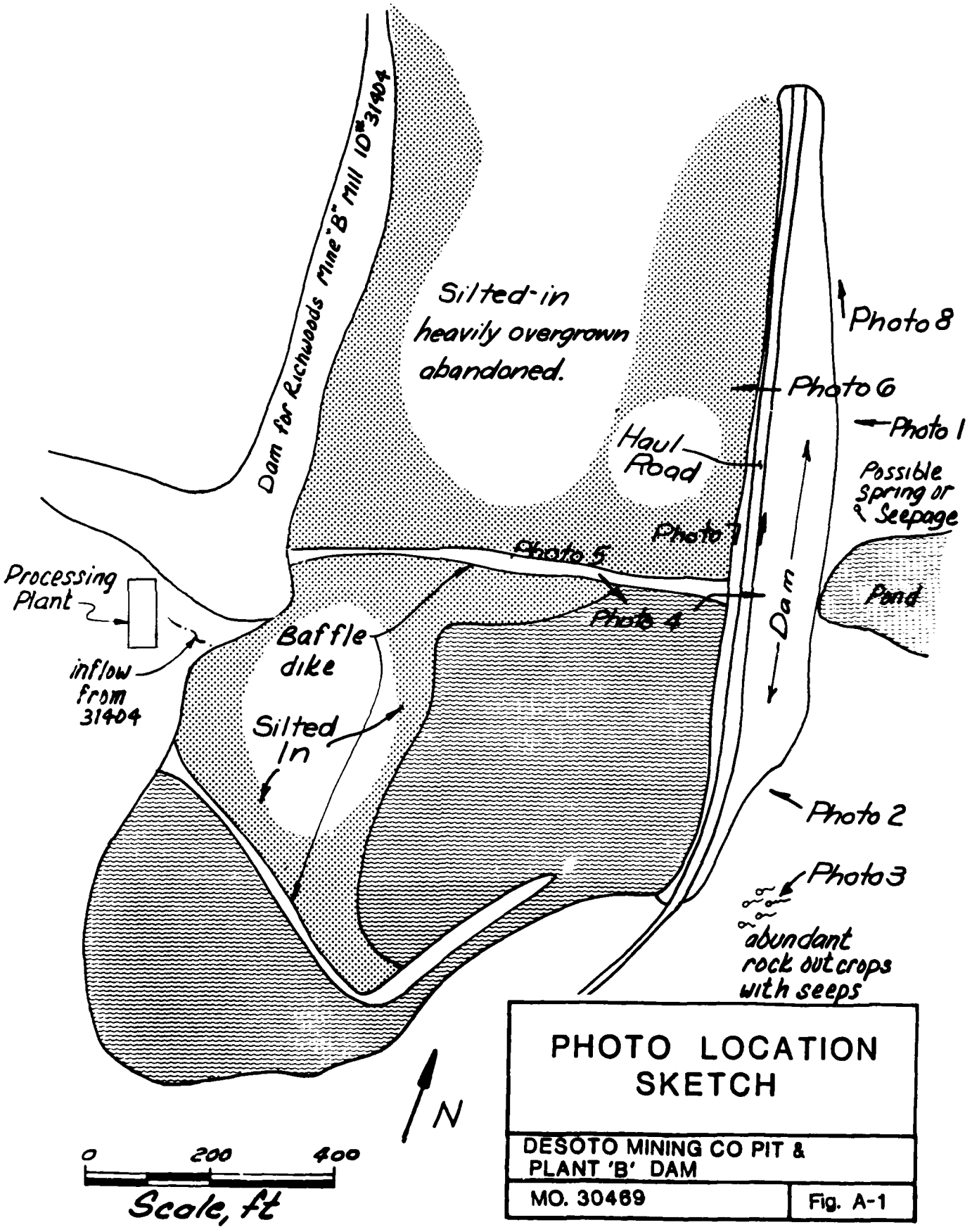
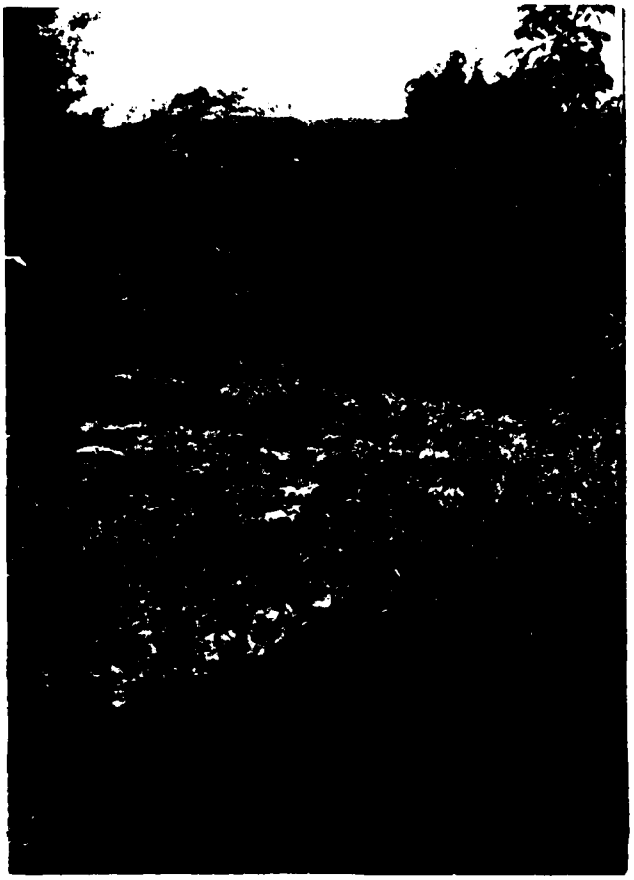


PHOTO LOCATION SKETCH

DESOTO MINING CO PIT & PLANT 'B' DAM

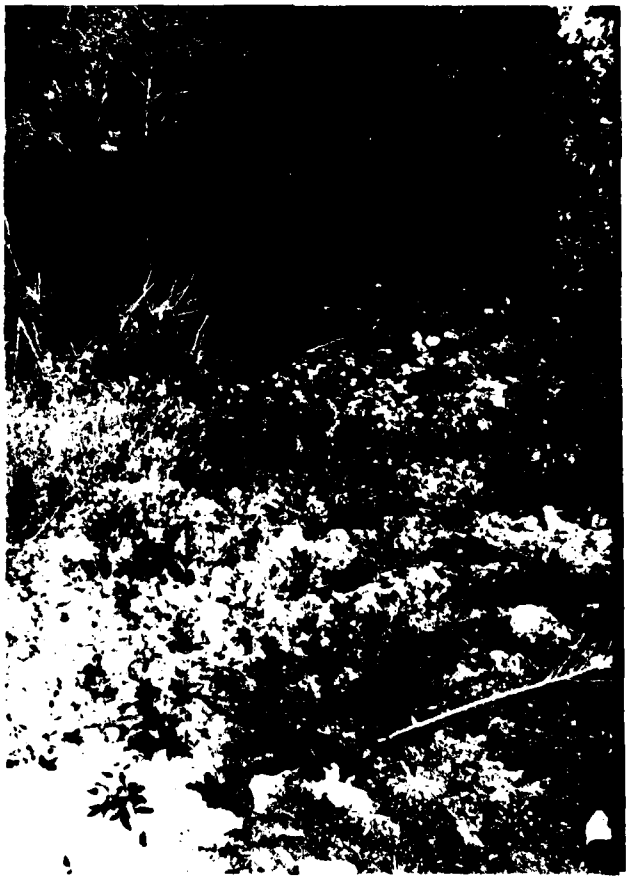
MO. 30469 | Fig. A-1

1. "Bullrock" cover on face of dam showing sliding to toe. Looking west (upstream).



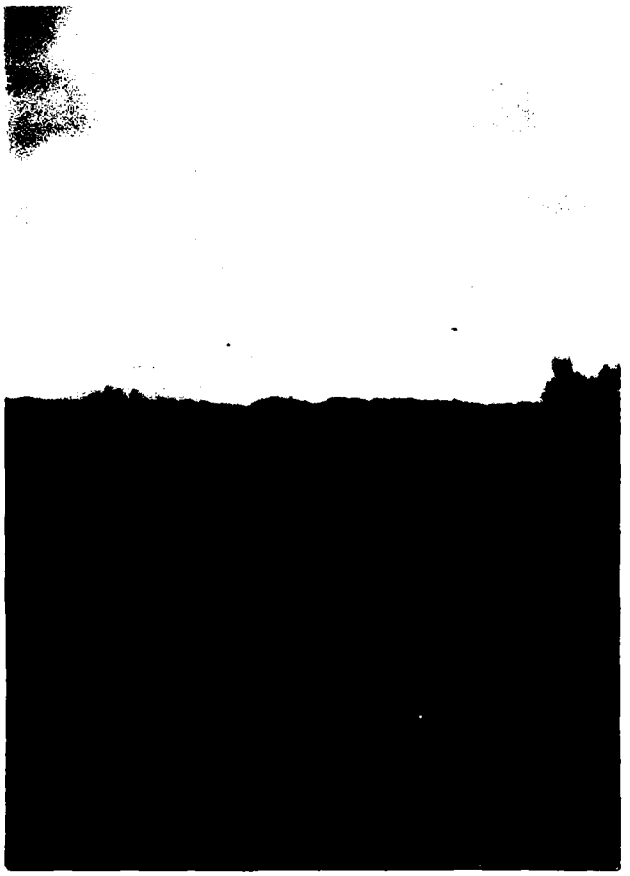
2. Exposed bedrock at toe of dam. Looking west (upstream).

3. Seepage from near bedrock contact on right abutment.



4. "Bullrock" slope cover and pond at toe of dam. Looking east (downstream).

5. Vegetation on upstream side of dam crest. Looking southeast from baffle dike in center of reservoir.



6. Foreground is dense vegetation on north half of impoundment. Dam 31404 in background. Looking west.

7. Bullrock and clay matrix dumped as slope erosion protection. Looking north along dam crest.

8. Overland erosion channel at toe of dam. Looking northwest.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{l^{0.8}(s+\ell)^{0.7}}{1900\, Y^{0.5}} \quad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet
$s = \frac{1000}{CN} - 10$ where CN = hydrologic soil curve number
Y = average watershed land slope in percent

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \quad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_c \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_c = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 10 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF estimates and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - high water mark

(2) Probable Maximum Storm - minimum top of dam

Because this is a tailings dam which has no outlet structure the water surface elevation for the 1 and 10 percent probability flood was set at the high water mark

f. Spillway Rating Curve. The basic weir equation was utilized to compute the spillway rating curve. The weir equation is as follows:

$$Q = CLH^{3/2}$$

where Q = discharge in cubic feet per second
L = effective length of spillway in feet
C = coefficient of discharge (2.5 to 3.1)
H = total head over spillway in feet

B.2 Pertinent Data

a. Drainage area. 0.37 mi^2

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 48 hours duration was divided into 10 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.29 hrs

d. Hydrologic soil group. C

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 92
2. For 1 and 10 percent probability-of-occurrence events AMC II - Curve Number 84

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Richwoods SE 7.5 minute quadrangle map. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The spillway rating curve was computed by the intrinsic formula within the HEC-1 program, with pertinent spillway data entered on the $$ cards.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 834 ft, the low area on the dam crest. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was also 834 ft.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********
    1                 A1      DAM NO 31404 RICHWOODS MINE 8, MILL
    2                 A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB NO. 79C1009
    3                 A3       PROBABLE MAXIMUM FLOOD(PMF) ANALYSIS
    4                 B    288        0       10       -0       -0       -0       -0       -0       -0       -0
    5                 B1     5
    6                 J    1          5        1
    7                 J1  .25      .50      .75      1.0
    8                 K      0  INFLOW                                      1
    9                 K1       INFLOW HYDROGRAPH CALCULATION
   10                 M      1        2    0.15
   11                 P      0.      26.     102.     120.     130.     140.
   12                 T                                                          -1       -92              0.70
   13                 W2             0.27
   14                 X     -1     -.05        5
   15                 K      1      DAM                                    1
   16                 K1       OUTFLOW HYDROGRAPH,ROUTING AND OVERTOPPING ANALYSIS
   17                 Y                                 1
   18                 YT     1                                        -872.
   19                 SA     0.      54.      64.      76.      84.
   20                 SE   825.     860.     872.     880.     890.
   21                 SS   872.        0      2.9      1.5
   22                 SD   872.      2.6      1.5
   23                 SL     0      320      600     1230     2210     2560
   24                 SV   872      878      880      882      884      886
   25                 K      0   Q-IN2                                  1
   26                 K1   DAM NO 30469 PIT/PLANT B, MULTI-RATIO PMF RUNOFF COMPS.
   27                 M      1        2      .22                    1                 1
   28                 P      0      26.      102      120      130      140
   29                 T                                                          -1       -93              .15
   30                 W2             0.29
   31                 X     -1     -.05        5
   32                 K      2   Q-IN2
   33                 K      1     DAM2                                   1
   34                 K1   DAM NO 30469 PIT/PLANT B- PMF COMBINED HYDROGRAPH CAPACITY/OVERTOPPING
   35                 Y                                 1        1
   36                 YT     1                                        -834
   37                 SA     0.      15.      21.      36.      64.
   38                 SE   800.     832.     834.     840.     860.
   39                 SS   834         0      2.9      1.5
   40                 SD   834       2.6      1.5
   41                 SL     0.      45.     100.     140.     190.     280.     350.     510.
   42                 SV   834.     834.9    835.     835.9    836.     837.     838.     839.
   43                 K     99
```

Input Data
Various PMF Events
Desoto Mining Company
Pit and Plant B Dam
MO 30469

B4

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 01 APR 80
****

RUN DATE: 28 JUL 83
TIME: 09.12.17

DAM NO 31604 RICHWOODS MINE 9. MILL
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB NO. 79CH009
PROBABLE MAXIMUM FLOW(PMF) ANALYSIS

JOB SPECIFICATION

NU	NMR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	-0	-0	-0	-0	-0	-0	-0

JOPER	NWT	LROPT	TRACE
5	-0	-0	-0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= .25 .50 .75 1.00

****

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH CALCULATION

	ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW		0	-0	-0	-0	1	-0	-0	-0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.15	-0.	.15	-0.	-0.	-0	-0	-0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.	26.00	102.00	120.00	130.00	140.00	-0.	-0.

TRSPC COMPUTED BY THE PROGRAM IS .400

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-92.00	-0.	.70

CURVE NO = -92.00 WETNESS = -1.00 EFFECT CN = 92.00

Input Data
Various PMF Events
Desoto Mining Company
Pit and Plant B Dam
MO 30469

B5

SPFE	P6	R6	R12	R24	R48	R72	R96
0.	26.00	102.00	120.00	130.00	140.00	-0.	-0.

ENSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
-0	-0.	-0.	1.00	-0.	-0.	1.00	-1.00	-92.00	-0.	.70

CURVE NO = -92.00 WETNESS = -1.00 EFFECT CN = 92.00

UNIT HYDROGRAPH DATA

TC= -0. LAG= .27

RECESSION DATA

STRTQ= -1.00 QRCSN= -.05 RTIOR= 5.00

TIME INCREMENT TOO LARGE--IN40 IS GT LAG/2!

UNIT HYDROGRAPH 10 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= .27 VOL= 1.00

50.	205.	158.	70.	33.	19.	7.	5.	2.	1.		

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.00	.00	.00	0.	1.02	.10	145	.02	.02	.00	3.
1.01	.20	2	.00	.00	.00	0.	1.02	.20	146	.02	.02	.00	7.
1.01	.30	3	.00	.00	.00	1.	1.02	.30	147	.02	.02	.00	10.
1.01	.40	4	.00	.00	.00	1.	1.02	.40	148	.02	.02	.00	12.
1.01	.50	5	.00	.00	.00	1.	1.02	.50	149	.02	.02	.00	12.
1.01	1.00	6	.00	.00	.00	1.	1.02	1.00	150	.02	.02	.00	13.
1.01	1.10	7	.00	.00	.00	1.	1.02	1.10	151	.02	.02	.00	13.
1.01	1.20	8	.00	.00	.00	1.	1.02	1.20	152	.02	.02	.00	13.
1.01	1.30	9	.00	.00	.00	1.	1.02	1.30	153	.02	.02	.00	13.
1.01	1.40	10	.00	.00	.00	1.	1.02	1.40	154	.02	.02	.00	13.
1.01	1.50	11	.00	.00	.00	1.	1.02	1.50	155	.02	.02	.00	13.
1.01	2.00	12	.00	.00	.00	1.	1.02	2.00	156	.02	.02	.00	13.
1.01	2.10	13	.00	.00	.00	1.	1.02	2.10	157	.02	.02	.00	13.
1.01	2.20	14	.00	.00	.00	1.	1.02	2.20	158	.02	.02	.00	13.
1.01	2.30	15	.00	.00	.00	1.	1.02	2.30	159	.02	.02	.00	13.
1.01	2.40	16	.00	.00	.00	1.	1.02	2.40	160	.02	.02	.00	13.
1.01	2.50	17	.00	.00	.00	1.	1.02	2.50	161	.02	.02	.00	13.
1.01	3.00	18	.00	.00	.00	1.	1.02	3.00	162	.02	.02	.00	13.
1.01	3.10	19	.00	.00	.00	1.	1.02	3.10	163	.02	.02	.00	13.
1.01	3.20	20	.00	.00	.00	1.	1.02	3.20	164	.02	.02	.00	13.
1.01	3.30	21	.00	.00	.00	1.	1.02	3.30	165	.02	.02	.00	13.
1.01	3.40	22	.00	.00	.00	1.	1.02	3.40	166	.02	.02	.00	13.
1.01	3.50	23	.00	.00	.00	1.	1.02	3.50	167	.02	.02	.00	13.
1.01	4.00	24	.00	.00	.00	1.	1.02	4.00	168	.02	.02	.00	13.
1.01	4.10	25	.00	.00	.00	1.	1.02	4.10	169	.02	.02	.00	13.
1.01	4.20	26	.00	.00	.00	1.	1.02	4.20	170	.02	.02	.00	13.
1.01	4.30	27	.00	.00	.00	1.	1.02	4.30	171	.02	.02	.00	13.
1.01	4.40	28	.00	.00	.00	1.	1.02	4.40	172	.02	.02	.00	13.
1.01	4.50	29	.00	.00	.00	1.	1.02	4.50	173	.02	.02	.00	13.
1.01	5.00	30	.00	.00	.00	1.	1.02	5.00	174	.02	.02	.00	13.
1.01	5.10	31	.00	.00	.00	1.	1.02	5.10	175	.02	.02	.00	13.
1.01	5.20	32	.00	.00	.00	1.	1.02	5.20	176	.02	.02	.00	13.
1.01	5.30	33	.00	.00	.00	1.	1.02	5.30	177	.02	.02	.00	13.
1.01	5.40	34	.00	.00	.00	1.	1.02	5.40	178	.02	.02	.00	13.
1.01	5.50	35	.00	.00	.00	1.	1.02	5.50	179	.02	.02	.00	13.
1.01	6.00	36	.00	.00	.00	1.	1.02	6.00	180	.02	.02	.00	13.
1.01	6.10	37	.01	.01	.00	1.	1.02	6.10	181	.10	.10	.00	20.
1.01	6.20	38	.01	.01	.00	2.	1.02	6.20	182	.10	.10	.00	36.
1.01	6.30	39	.01	.01	.00	3.	1.02	6.30	183	.10	.10	.00	49.
1.01	6.40	40	.01	.01	.00	3.	1.02	6.40	184	.10	.10	.00	58.

Input Data
Various PMF Events
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1.01	6.20	38	.01	.01	.00	2.	1.02	6.20	182	.10	.10	.00	
1.01	6.30	39	.01	.01	.00	3.	1.02	6.30	183	.10	.10	.00	49.
1.01	6.40	40	.01	.01	.00	3.	1.02	6.40	184	.10	.10	.00	55.
1.01	6.50	41	.01	.01	.00	3.	1.02	6.50	185	.10	.10	.00	57.
1.01	7.00	42	.01	.01	.00	3.	1.02	7.00	186	.10	.10	.00	59.
1.01	7.10	43	.01	.01	.00	3.	1.02	7.10	187	.10	.10	.00	59.
1.01	7.20	44	.01	.01	.00	3.	1.02	7.20	188	.10	.10	.00	59.
1.01	7.30	45	.01	.01	.00	3.	1.02	7.30	189	.10	.10	.00	60.
1.01	7.40	46	.01	.01	.00	3.	1.02	7.40	190	.10	.10	.00	60.
1.01	7.50	47	.01	.01	.00	3.	1.02	7.50	191	.10	.10	.00	60.
1.01	8.00	48	.01	.01	.00	3.	1.02	8.00	192	.10	.10	.00	60.
1.01	8.10	49	.01	.01	.00	3.	1.02	8.10	193	.10	.10	.00	60.
1.01	8.20	50	.01	.01	.00	3.	1.02	8.20	194	.10	.10	.00	60.
1.01	8.30	51	.01	.01	.00	3.	1.02	8.30	195	.10	.10	.00	60.
1.01	8.40	52	.01	.01	.00	3.	1.02	8.40	196	.10	.10	.00	60.
1.01	8.50	53	.01	.01	.00	3.	1.02	8.50	197	.10	.10	.00	60.
1.01	9.00	54	.01	.01	.00	3.	1.02	9.00	198	.10	.10	.00	60.
1.01	9.10	55	.01	.01	.00	3.	1.02	9.10	199	.10	.10	.00	60.
1.01	9.20	56	.01	.01	.00	3.	1.02	9.20	200	.10	.10	.00	60.
1.01	9.30	57	.01	.01	.00	3.	1.02	9.30	201	.10	.10	.00	60.
1.01	9.40	58	.01	.01	.00	3.	1.02	9.40	202	.10	.10	.00	60.
1.01	9.50	59	.01	.01	.00	3.	1.02	9.50	203	.10	.10	.00	60.
1.01	10.00	60	.01	.01	.00	3.	1.02	10.00	204	.10	.10	.00	60.
1.01	10.10	61	.01	.01	.00	3.	1.02	10.10	205	.10	.10	.00	60.
1.01	10.20	62	.01	.01	.00	3.	1.02	10.20	206	.10	.10	.00	60.
1.01	10.30	63	.01	.01	.00	3.	1.02	10.30	207	.10	.10	.00	60.
1.01	10.40	64	.01	.01	.00	4.	1.02	10.40	208	.10	.10	.00	60.
1.01	10.50	65	.01	.01	.00	4.	1.02	10.50	209	.10	.10	.00	60.
1.01	11.00	66	.01	.01	.00	4.	1.02	11.00	210	.10	.10	.00	60.
1.01	11.10	67	.01	.01	.00	4.	1.02	11.10	211	.10	.10	.00	60.
1.01	11.20	68	.01	.01	.00	4.	1.02	11.20	212	.10	.10	.00	60.
1.01	11.30	69	.01	.01	.00	4.	1.02	11.30	213	.10	.10	.00	60.
1.01	11.40	70	.01	.01	.00	4.	1.02	11.40	214	.10	.10	.00	60.
1.01	11.50	71	.01	.01	.00	4.	1.02	11.50	215	.10	.10	.00	60.
1.01	12.00	72	.01	.01	.00	4.	1.02	12.00	216	.10	.10	.00	60.
1.01	12.10	73	.03	.02	.01	5.	1.02	12.10	217	.35	.35	.00	82.
1.01	12.20	74	.03	.02	.01	8.	1.02	12.20	218	.35	.35	.00	139.
1.01	12.30	75	.03	.02	.00	11.	1.02	12.30	219	.35	.35	.00	172.
1.01	12.40	76	.03	.02	.00	12.	1.02	12.40	220	.35	.35	.00	189.
1.01	12.50	77	.03	.02	.00	13.	1.02	12.50	221	.35	.35	.00	198.
1.01	13.00	78	.03	.02	.00	13.	1.02	13.00	222	.35	.35	.00	202.
1.01	13.10	79	.03	.03	.00	14.	1.02	13.10	223	.42	.42	.00	209.
1.01	13.20	80	.03	.03	.00	15.	1.02	13.20	224	.42	.42	.00	229.
1.01	13.30	81	.03	.03	.00	16.	1.02	13.30	225	.42	.42	.00	236.
1.01	13.40	82	.03	.03	.00	16.	1.02	13.40	226	.42	.42	.00	242.
1.01	13.50	83	.03	.03	.00	16.	1.02	13.50	227	.42	.42	.00	244.
1.01	14.00	84	.03	.03	.00	16.	1.02	14.00	228	.42	.42	.00	245.
1.01	14.10	85	.04	.04	.00	17.	1.02	14.10	229	.53	.53	.00	259.
1.01	14.20	86	.04	.04	.00	19.	1.02	14.20	230	.53	.53	.00	277.
1.01	14.30	87	.04	.04	.00	20.	1.02	14.30	231	.53	.53	.00	294.
1.01	14.40	88	.04	.04	.00	21.	1.02	14.40	232	.53	.53	.00	301.
1.01	14.50	89	.04	.04	.00	21.	1.02	14.50	233	.53	.53	.00	304.
1.01	15.00	90	.04	.04	.00	21.	1.02	15.00	234	.53	.53	.00	306.
1.01	15.10	91	.04	.03	.00	21.	1.02	15.10	235	.48	.48	.00	303.
1.01	15.20	92	.06	.06	.00	23.	1.02	15.20	236	.91	.91	.00	322.
1.01	15.30	93	.11	.10	.01	31.	1.02	15.30	237	1.45	1.45	.00	437.
1.01	15.40	94	.26	.26	.02	58.	1.02	15.40	238	3.63	3.63	.00	807.
1.01	15.50	95	.08	.08	.00	83.	1.02	15.50	239	1.05	1.05	.00	1190.
1.01	16.00	96	.05	.05	.00	71.	1.02	16.00	240	.64	.64	.00	984.
1.01	16.10	97	.04	.04	.00	48.	1.02	16.10	241	.50	.49	.00	659.
1.01	16.20	98	.04	.04	.00	34.	1.02	16.20	242	.50	.49	.00	469.
1.01	16.30	99	.04	.04	.00	27.	1.02	16.30	243	.50	.49	.00	371.
1.01	16.40	100	.04	.04	.00	24.	1.02	16.40	244	.50	.49	.00	326.
1.01	16.50	101	.04	.04	.00	23.	1.02	16.50	245	.50	.49	.00	309.

Input Data
Various PMF Events
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1.01	16.30	99	.04	.04	.00	27.	1.02	16.30	243	.50	.49	.00	3
1.01	16.40	100	.04	.04	.00	24.	1.02	16.40	244	.50	.49	.00	328.
1.01	16.50	101	.04	.04	.00	23.	1.02	16.50	245	.50	.49	.00	309.
1.01	17.00	102	.04	.04	.00	22.	1.02	17.00	246	.50	.49	.00	296.
1.01	17.10	103	.03	.03	.00	21.	1.02	17.10	247	.39	.39	.00	281.
1.01	17.20	104	.03	.03	.00	19.	1.02	17.20	248	.39	.39	.00	257.
1.01	17.30	105	.03	.03	.00	18.	1.02	17.30	249	.39	.39	.00	240.
1.01	17.40	106	.03	.03	.00	17.	1.02	17.40	250	.39	.39	.00	232.
1.01	17.50	107	.03	.03	.00	17.	1.02	17.50	251	.39	.39	.00	229.
1.01	18.00	108	.03	.03	.00	17.	1.02	18.00	252	.39	.39	.00	227.
1.01	18.10	109	.00	.00	.00	15.	1.02	18.10	253	.03	.03	.00	195.
1.01	18.20	110	.00	.00	.00	9.	1.02	18.20	254	.03	.03	.00	122.
1.01	18.30	111	.00	.00	.00	5.	1.02	18.30	255	.03	.03	.00	66.
1.01	18.40	112	.00	.00	.00	4.	1.02	18.40	256	.03	.03	.00	52.
1.01	18.50	113	.00	.00	.00	3.	1.02	18.50	257	.03	.03	.00	44.
1.01	19.00	114	.00	.00	.00	3.	1.02	19.00	258	.03	.03	.00	38.
1.01	19.10	115	.00	.00	.00	2.	1.02	19.10	259	.03	.03	.00	32.
1.01	19.20	116	.00	.00	.00	2.	1.02	19.20	260	.03	.03	.00	27.
1.01	19.30	117	.00	.00	.00	2.	1.02	19.30	261	.03	.03	.00	23.
1.01	19.40	118	.00	.00	.00	1.	1.02	19.40	262	.03	.03	.00	20.
1.01	19.50	119	.00	.00	.00	1.	1.02	19.50	263	.03	.03	.00	20.
1.01	20.00	120	.00	.00	.00	2.	1.02	20.00	264	.03	.03	.00	20.
1.01	20.10	121	.00	.00	.00	2.	1.02	20.10	265	.03	.03	.00	20.
1.01	20.20	122	.00	.00	.00	2.	1.02	20.20	266	.03	.03	.00	20.
1.01	20.30	123	.00	.00	.00	2.	1.02	20.30	267	.03	.03	.00	20.
1.01	20.40	124	.00	.00	.00	2.	1.02	20.40	268	.03	.03	.00	20.
1.01	20.50	125	.00	.00	.00	2.	1.02	20.50	269	.03	.03	.00	20.
1.01	21.00	126	.00	.00	.00	2.	1.02	21.00	270	.03	.03	.00	20.
1.01	21.10	127	.00	.00	.00	2.	1.02	21.10	271	.03	.03	.00	20.
1.01	21.20	128	.00	.00	.00	2.	1.02	21.20	272	.03	.03	.00	20.
1.01	21.30	129	.00	.00	.00	2.	1.02	21.30	273	.03	.03	.00	20.
1.01	21.40	130	.00	.00	.00	2.	1.02	21.40	274	.03	.03	.00	20.
1.01	21.50	131	.00	.00	.00	2.	1.02	21.50	275	.03	.03	.00	20.
1.01	22.00	132	.00	.00	.00	2.	1.02	22.00	276	.03	.03	.00	20.
1.01	22.10	133	.00	.00	.00	2.	1.02	22.10	277	.03	.03	.00	20.
1.01	22.20	134	.00	.00	.00	2.	1.02	22.20	278	.03	.03	.00	20.
1.01	22.30	135	.00	.00	.00	2.	1.02	22.30	279	.03	.03	.00	20.
1.01	22.40	136	.00	.00	.00	2.	1.02	22.40	280	.03	.03	.00	20.
1.01	22.50	137	.00	.00	.00	2.	1.02	22.50	281	.03	.03	.00	20.
1.01	23.00	138	.00	.00	.00	2.	1.02	23.00	282	.03	.03	.00	20.
1.01	23.10	139	.00	.00	.00	2.	1.02	23.10	283	.03	.03	.00	20.
1.01	23.20	140	.00	.00	.00	2.	1.02	23.20	284	.03	.03	.00	20.
1.01	23.30	141	.00	.00	.00	2.	1.02	23.30	285	.03	.03	.00	20.
1.01	23.40	142	.00	.00	.00	2.	1.02	23.40	286	.03	.03	.00	20.
1.01	23.50	143	.00	.00	.00	2.	1.02	23.50	287	.03	.03	.00	20.
1.02	0.	144	.00	.00	.00	2.	1.03	0.	288	.03	.03	.00	20.
									SUM	29.12	28.91	.31	16783.
										(740.11	732.11	8.11	474.68)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1150.	337.	109.	58.	16743.
CMS	33.	10.	3.	2.	474.
INCHES		20.89	28.99	29.84	29.84
MM		530.26	685.60	732.61	732.61
AC-FT		157.	216.	231.	231.
THOUS CU M		206.	266.	284.	284.

Input Data
Various PMF Events
Desoto Mining Company
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HYDROGRAPH AT STAINFLOW FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .25	RATIO 2 .50	RATIO 3 .75	RATIO 4 1.00
HYDROGRAPH AT	INFLOW	.13	1	288.	575.	863.	1150.
		(.39)	(	8.14)(	16.29)(	24.43)(	32.57)(
ROUTED TO	DAM	.13	1	26.	102.	204.	331.
		(.39)	(	.75)(	2.89)(	5.79)(	9.38)(
HYDROGRAPH AT	D-1V2	.22	1	509.	1017.	1526.	2035.
		(.57)	(	14.40)(	28.81)(	43.21)(	57.62)(
2 COMBINED	D-1V2	.37	1	519.	1068.	1644.	2239.
		(.96)	(	14.70)(	30.24)(	46.54)(	63.41)(
ROUTED TO	DAV2	.37	1	313.	763.	1268.	1891.
		(.96)	(	8.85)(	21.60)(	35.90)(	51.00)(

Output Summary
Various PMF Events
Desoto Mining Company
Pit and Plant B Dam
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SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	834.00	834.00	834.00
STORAGE	196.	196.	196.
OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.25	835.48	1.48	229.	313.	48.00	40.17	0.
.50	836.12	2.12	245.	763.	48.00	40.17	0.
.75	836.60	2.60	258.	1268.	48.00	40.17	0.
1.00	836.99	2.99	269.	1801.	48.00	40.17	0.

Output Summary
Various PMF Events
Desoto Mining Company
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